Sandia National Laboratories
Waste Isolation Pilot Plant

Analysis Plan for an RH-TRU Impact Assessment with EPA Mandated Baseline (RHEPA)

AP-074

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1. INTRODUCTION AND OBJECTIVES

This analysis plan directs a study to assess the impact on repository performance of remote-handled transuranic waste (RH-TRU) and RH-TRU mixed waste characterized using acceptable knowledge (AK). The first RH-TRU impact assessment [Vaughn and Lord, July 13, 2000] used the 1996 Compliance Certification Application (CCA) calculations as a baseline. Variance from the baseline was calculated for certain RH-TRU non-radionuclide and radionuclide bounding inventories. The original RH-TRU impact assessment will be referenced in this document as RHIA (for **RH-**TRU inventory **I**mpact **A**ssessment with CCA base line).

A second impact assessment study [Hadgu, Vaughn, and Lord, November 24, 2000] was similar to the RHIA, but used the performance assessment verification test, PAVT, as a baseline. This impact assessment used a different implementation of the PAVT database and certain codes had been revised since the 1997 PAVT (see Table 2). This impact assessment will be referenced in this document as RHVT (for **RH**-TRU inventory impact assessment with PA**VT** base line).

In order to address the database and code version concerns with the RHVT calculations, this impact assessment uses the 1997 PAVT views of the database. The software criteria for this calculation were determined by meeting with EPA (12/01/00). The codes to be used are PAVT versions or PAVT versions with changes necessary to accommodate year 2000 compliance, updates of the VAX Alpha operation system to version 7.2, to represent bounding values of inventories, or code changes to accommodate the change to the Ingres database system. The code versions used in the PAVT, RHVT, and this study (RHEPA) are given in Table 2. In this analysis the bounding nuclide inventory will be represented by ^{239}PU instead of ^{240}PU, which was used in the RHIA and RHVT. This is done because ^{239}PU has a longer half life than ^{240}PU resulting in slightly greater releases. Further, the Curie loading of the nuclide inventory will be increased to the limit mandated by the Land Withdrawal Act contained in 40 CFR 191 and 194 [EPA, 1996]. New to this analysis will be a 300-year calculation for the baseline, bounding cellulosics and bounding water. These deterministic calculations will use mean database parameter values and investigate undisturbed releases to the land withdrawal boundary. This impact assessment will be referenced in this document as RHEPA (for **RH**-TRU inventory impact assessment with **EPA** mandated base line).

Performance-based studies seek to reduce risks across the entire TRU waste complex. This is accomplished by increased generator site and worker safety through decreased exposure during characterization of RH wastes, while maintaining the same margin of safety associated with transportation, WIPP site operations, handling, disposal, and repository storage. This performance-based approach identifies for characterization only those components and properties of the RH-TRU inventory necessary to assure compliance with all regulations and assure adequate safety to the environment and population.

The conclusions from the safety assessments associated with waste isolation in the WIPP indicate that the only RH-TRU waste characterization information required to demonstrate a continued and acceptable margin of safety are knowledge of:

- the total volume of the RH-TRU waste,
- the total Curie content of the RH-TRU waste, and
- no prohibited items contained in the waste.

Any other information about the RH-TRU waste is unnecessary from a repository performance perspective and would unnecessarily expose generator site workers to further risk.

Demonstration of safe isolation of the RH-TRU waste in the repository after closure requires two determinations:

- all the EPA regulations contained in 40 CFR 191 and 194 (REF., EPA 1996) are met, and that
- all RCRA related regulatory requirements are met.

Item two requires demonstrating over the RCRA time frame (assumed to be the first 300 years after closure) that:

- no RCRA controlled substances migrate away from the vicinity of the repository in the gas phase,
- no RCRA controlled substances migrate away from the vicinity of the repository in the brine phase, and
- no prohibited items are contained within the waste.

Demonstration of item one will be discussed based on the 300-year calculation results of this study.

2. APPROACH

2.1 Inventory of radioactive and non-radioactive components

The RH-TRU waste contains inventory components that are both radioactive and non-radioactive. Examination of the CCA results [Helton, 1998] indicates that the non-radioactive components that have the potential to impact repository performance are 1) the amount of free water, 2) the amount of corrodible metals, and 3) the amount of bio-degradables. The radioactive components that account for most radionuclide release are ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{240}Pu.

2.2 Description of Calculation methods

Bounding estimates for the non-radioactive components identified above will be selected based on volumetric constraints and assumes that half of the RH volume is made up of each component. Bounding estimates for the radioactive components assume that a nuclide component (^{239}Pu) is set to the maximum Curie loading as specified by the Land Withdrawal Act contained in 40 CFR 191 and 194 [EPA, 1996]. These bounding values will be designed for maximum regulatory impact, in the sense that they have been selected with the expectation that they would never be exceeded. It follows that if repository performance is sufficiently insensitive to these upper bounds, then characterization of the RH waste is not required since repository performance would be acceptable regardless of the RH inventory. Table 1 from [Vaughn and Lord, 2000] shows the computational sets with bounding changes to the quantities of the important RH-TRU inventory components that have been identified. These computational sets will be designed to investigate the impact of radioactive and non-radioactive components on the performance of the WIPP repository. For the current analysis the base line in the computational sets will be PAVT [PAVT, 1997] baseline.

The current analysis will be based on the same principles as the RHIA analysis. Thus, findings of the screening runs of the RHIA also apply to this analysis. Based on the results of the screening runs of the RHIA analysis [Vaughn and Lord, 2000] the current analysis will use only four of the original computational sets described in Table 1. These are the PAVT baseline, Computational Sets 2 (bounding plastics), 3 (bounding water), and 9 (bounding ^{239}Pu, while maintaining the waste unit factor, WUF, of 3.44).

Sets of simulations will be conducted in the same way as in the RHIA calculations. Each key RH-TRU inventory component will be fixed at its bounding value, while holding all other RH-TRU inventory components at their fixed PAVT baseline values. All other parameters (non-RH-TRU parameters) will be the same as the values used in the PAVT.

For this study two time scales will be considered for the PA calculations. The first time scale is 10,000 years and is intended to determine the impact of the bounding inventory assumptions associated with the RH-TRU waste on long term repository performance. The mean Complimentary Cumulative Distribution Functions, CCDFs, will be generated for this time scale and will include undisturbed and human intrusion scenarios. A comparison of the baseline RHEPA with the PAVT baseline will demonstrate that the calculations replicate the PAVT baseline results. Evaluation of the impacts will be made by direct comparison between the bounding component mean CCDF and the baseline mean CCDF. The analysis will also include a 300-year time scale evaluation of RCRA related regulatory requirements. This evaluation will use mean database parameter values to perform three deterministic runs representing the baseline, bounding cellulosics, and bounding water.

All calculations will use the EPA approved PAVT input data sets as a baseline so that the underlying uncertainty captured in the PAVT will be preserved [PAVT, 1997]. An upper bound for each of the key RH-TRU inventory components will be selected and added to the input file one at a time. There is no associated uncertainty in the bounding RH-TRU inventory parameters, because they are bounding values over all scenarios. This approach will result in multiple sets of simulations. This results in one set of future histories or realizations for each change to the RH-TRU inventory parameters.

Table 1: Description of Computational Sets

Computational Sets	Description and Assumptions
1. CCA BASELINE	Re-run or re-use the existing 1996 CCA calculations for the Baseline. This includes all 569 CH-TRU waste streams and 1 RH-TRU waste bin (equivalent to 401 RH-TRU waste streams). Volumes for CH- and RH-TRU are set at 5.95E+06 ft^3 (1.68485E+05 m^3) and 0.25E+06 ft^3 (7.07921E+03 m^3), respectively. Material mass values are determined from the TWBIR, [BIR-2 1996] and radionuclide inventory information is that derived by EPAUNI (Sanchez 1997) and previously used in the 1996 CCA.
2. Max RH-TRU Plastics	This computational set resembles the Baseline, with the exception that the material properties of the RH-TRU (only) waste matrices have been set to zero with the exception of the biodegradable components, which are to be set to a realistic maximum. Consideration for this computational set is the need to investigate the relative significance of gas generation potential due to biodegradation. Thus the material property for this set corresponds to cellulosics, plastics, or rubbers whichever component is the greater contributor. Plastics are the greater contributors due to greater carbon atom equivalence and theoretical density compared to cellulosics or rubbers. The maximum emplacement density [BIR-2 1996] for plastics (620. kg/m^3) used in this set is greater than that identified for a waste surrogate composed of pure plastics (theoretical density of 1200 kg/m^3) and using a loading porosity of 0.50 (600 kg/m^3). Therefore, a value of 620 kg/m^3 will be used for the maximum density of plastics to be emplaced in the RH canisters. The other non- biodegradable components of the waste (RH and CH) will be held at their CCA values. Therefore, when RH waste plastics are maximized, cellulose is 0, rubber is 0, iron is CCA baseline value, and water is at CCA baseline value. For CH waste everything is as in the CCA baseline.
3. Max RH-TRU H_2O	This computational set is similar to Set #2, except that water (flooded RH-TRU canisters) is investigated. For this analysis the maximum mass of water to be contained in the RH canisters will be the theoretical density of water (1000 kg/m^3) times the volume of the RH canisters times a 50% void volume. Therefore, for RH waste, water is maximized while plastics, cellulose, rubber, and iron are held at CCA baseline values. For CH waste all inventory is as in the CCA baseline.
4. Max RH-TRU Steel	This computational set is similar to Set #2, except that ferrous metals are investigated. Note, for this analysis the maximum mass of iron to be contained in the RH-TRU canister is the theoretical density of iron times the volume of the RH-TRU canisters times a 50% emplacement porosity. Therefore, for RH waste, iron is maximized while plastics, cellulose, rubber, and water are held at CCA baseline values. For CH waste all inventory is as in the CCA baseline.
5. RH-TRU ^{241}Am	The RH-TRU radionuclide contribution is parsed so that the influence of ^{241}Am on the performance assessment of WIPP can be identified. The parsed data corresponds to setting to zero the radionuclide information for all RH-TRU, except for that from ^{241}Am. The full RH Curie loading in 1995 (1.02 x 10^6 Ci) used in the CCA baseline consists of ^{241}Am. This initial inventory decays to 9.6 x 10^5 Ci by 2033. The loading and make up for the CH inventory will be the same as used in the CCA baseline.
6. RH-TRU ^{238}Pu	Same as computational set 5 except with 1.02e^6 Ci of ^{238}Pu in 1995. This inventory decays to 7.55 x 10^5 Ci by 2033.
7. RH-TRU ^{239}Pu	Same as computational set 5 except with ^{239}Pu. There is negligible decay by 2033.
8. RH-TRU ^{240}Pu	Same as computational set 5 except with ^{240}Pu. There is negligible decay by 2033.
9. Set RH-TRU ^{239}Pu at maximum allowed by the Land Withdrawal Act.	Same as computational set 7 except with 1995 inventory of 5.1x10^6 Curies ^{239}Pu RH-TRU. There is negligible decay of the initial inventory by 2033.

3. SOFTWARE LIST

The software used in the PAVT and RHVT, together with the software versions to be used in the RHEPA analysis is shown in Table 2.

Table 2: Comparison of Codes for the PAVT, RHVT and RHEPA Calculations

Code Name	PAVT Version	RHVT Version	RHEPA Version
ALGEBRACDB	2.35	2.35	2.35
BRAGFLO	4.10	4.50	4.10
CCDFGF	3.00 and 3.01	3.01 & 4.03	3.01
CCDFSUM	2.00	2.01	2.01
CUTTINGS_S	5.04	5.06	5.04A*
EPAUNI	1.14	N/A	1.14
GENMESH	6.08	6.08	6.08
ICSET	2.22	2.22	2.22
LHS	2.41	2.41	2.41
MATSET	9.00	9.04	9.00A*
NUTS	2.05	2.11	2.05A*
PANEL	3.60	4.00	3.60
POSTBRAG	4.00	4.01	4.00
POSTLHS	4.07	4.07	4.07
POSTSECOFL2D	4.04	N/A	N/A
POSTSECOTP2D	1.04	N/A	N/A
PREBRAG	6.00	6.40	6.00
PRELHS	2.10	2.24	2.10A*
PRESECOFL2D	4.05	N/A	N/A
PRESECOTP2D	1.22	N/A	N/A
RELATE	1.43	1.43	1.43
SECOFL2D	3.03	N/A	N/A
SECOTP2D	1.41	N/A	N/A
SUMMARIZE	2.15 and 2.20	2.20	2.20

* meet EPA Criteria

4. TASKS

Palmer Vaughn will handle coordination and management of the RH-TRU Impact Assessment with EPA mandated baseline. Jim Bean and Rodger Coman and his group will be responsible for calculation runs. Steven Tisinger will provide database support. Teklu Hadgu, Palmer Vaughn and Michael Lord will coordinate analysis and documentation. The technical, QA and management reviewers will be Jim Garner, Paula Painter and Kathryn Knowles, respectively. Report to be submitted to DOE/CBFO April 30, 2001.

5. SPECIAL CONSIDERATIONS

No special considerations have been identified for this analysis.

6. APPLICABLE PROCEDURES

Analyses will be conducted in accordance with the quality assurance (QA) procedures listed below.

Training: Training will be performed in accordance with the requirements in NP 2-1, Qualification and Training.

Parameter Development and Database Management: Selection and documentation of parameter values will follow SP 9-1. The database is to be managed in accordance with relevant technical procedure.

Computer Codes: New or revised computer codes that will be used in the analyses will be qualified in accordance with NP 19-1. See Table 2 for details. All other codes unchanged since the PAVT to be qualified under multi-use provisions of QAP 19-1. The platform on which the codes will be run is the Compaq Alpha, OpenVMS AXP, version 7.2.

Analysis and Documentation: Documentation will meet the applicable requirements in NP 9-1.

Reviews: Reviews will be conducted and documented in accordance with NP 6-1 and NP 9-1, as appropriate.

7. REFERENCES

BIR-2 1996: See DOE 1996.

CCA 1996, Bean, J.E., et. al., 1996, "Analysis Package for the Salado Flow Calculation (Task 1) of the Performance Assessment Analysis Supporting the Compliance

Certification Application (CCA)", Analysis Package. Albuquerque, NM: Sandia National Laboratory, Sandia WIPP Central Files WPO # 40514.

DOE, 1996, U.S. DOE (U.S. Department of Energy), “Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report”, DOE/CAO-95-1121, Revision 3, printed June 1996. [The TWBIR (BIR-2) establishes the methodology for grouping wastes of similar physical and chemical properties from across the U.S. DOE TRU waste system into a series of “waste profiles” that can be used as the basis for waste form discussions with regulatory agencies.], 1996.

EPA 1996: U.S. EPA (U.S. Environmental Protection Agency), “Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes”; Final Rule, 40 CFR 191, *Federal Register*, 61, 5224-5245, 1996.

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Teklu, H., Vaughn, P., and Lord, M., 2000, “RH-TRU Impact Assessment with PAVT Baseline (RHVT).” Sandia National Laboratories, Albuquerque, New Mexico. Sandia WIPP Central Files ERMS# 514554, November 24, 2000.